Chapter 4 Technical and Economic Feasibility Assessment

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THE purpose of this chapter is to lead you through the technical and economic feasibility assessment of biogas technology at a facility. This process involves several steps. First, the compatibility of existing manure management practices with potential digester types is examined. Then site specific data are collected using evaluation forms. These data are entered into FarmWare/RateVision, the decision support software developed by AgSTAR. It will perform the technical and economic feasibility analyses. Finally, the results from FarmWare/RateVision are evaluated and a final appraisal of project opportunities is performed.

It is expected that the owner/operator or the person most knowledgeable about the facility will be collecting data and performing this assessment. In some areas, NRCS may be contacted for assistance. See Appendix B for a list of contacts. Checklists and screening forms have been provided to assist you through the process. Additionally, sample case studies have been presented in Appendix E to assist you further.

To select an appropriate and cost effective biogas technology option(s), complete the following steps:

1. **Match a Digester to Your Facility.** Whether a digester can be integrated into a facility's existing or planned manure management system depends on the climate and solids content of the manure. Section 4-1 discusses this step in more detail.

2. **Complete Evaluation Forms.** These forms record the information required to complete the FarmWare assessment. A separate form is provided for swine and dairy facilities. Section 4-2 presents the screening forms and necessary directions.

3. **Enter Information into FarmWare.** The information from Step 2 is entered into FarmWare, the decision support software provided with this handbook (Appendix C). Section 4-3 discusses this step in more detail.

4. **Evaluate Results.** Using the results from the FarmWare analyses, a final appraisal of project opportunities can be performed. This process is presented in Section 4-4.

Each step is discussed in turn.

4-1. Match a Digester to Your Facility

The choice of which digester to use is driven primarily by the climate and characteristics of the existing manure management system, in particular how the system affects the total solids content of the manure.

As mentioned in Chapter 1, one of three digester types will be suitable for most manure management conditions: covered lagoon; complete mix digester; and plug-flow digester.

- **Covered Lagoon.** Covered lagoons require warm climates to be cost effective, unless odor management is the goal. They are used to store and treat liquid manure with less than 2 percent solids.

- **Complete Mix Digester.** Complete mix digesters are applicable in all climates. They can treat manure with solids in the range of about 3 to 10 percent.

- **Plug Flow Digester:** Plug flow digesters are applicable in all climates. They can treat only dairy manure with a range of about 11 to 13 percent total solids.

This section will help you decide which digester is suitable for your facility. First, the digesters appropriate for the climatic conditions at your facility are identified. Then the process of determining the total solids content of the manure is presented. Using the information from the first two steps, the digester appropriate for your facility is

determined. The table presented in Exhibit 4-4 outlines this selection process.

4-1.1 Where Is The Facility Located?

Temperature is one of the major factors affecting the growth of bacteria responsible for biogas production. Biogas production can occur anywhere between 39º and 155ºF (4º to 68ºC). As the temperature increases, the gas production rate also increases, up to a limit.

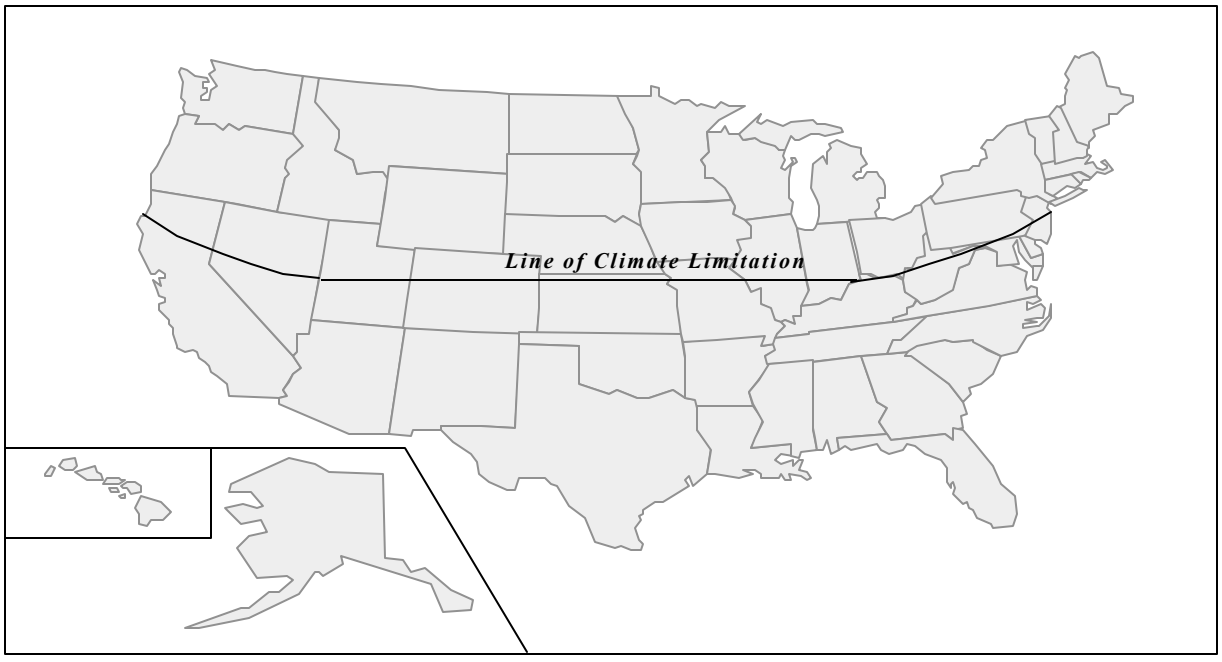
Complete mix digesters and plug flow digesters are usable in virtually all climates. Plug-flow digesters and complete-mix digesters use supplemental heat to ensure optimal temperature conditions in the 95º to 130ºF range (35º to 55ºC). Capturing waste heat is the preferred method for heating these types of digesters.

Covered lagoons generally do not use supplemental heat because there is not enough waste heat available to heat the large volume of dilution water. Lagoons require large capacities to treat the liquid manure properly at low temperatures; providing heat for these large capacities is expensive and usually not cost-effective. Therefore, covered lagoons for energy recovery are possible in warmer climates, where additional heat will not be required.

However, covered lagoons may be considered for use as an odor management system in colder climates. Since gas production varies by season, covered lagoons in these (colder) climates should be equipped with a simple flare system to combust the biogas produced in the lagoon. Flared gas makes a strong odor management statement. However, flaring available gas does not guarantee odor free manure availability for crop applications. Manure characteristics during crop application events are dependent upon lagoon sizing and operational parameters.

To determine which regions have a climate warm enough to install a covered lagoon for energy use, experts use a simple rule of thumb. Facilities in regions below the line of climate limitation (shown in Exhibit 4-1) should be warm enough to consider recovering biogas for energy use. In regions

Exhibit 4-1 Covered Lagoons for Energy Recovery - Below the Line of Climate Limitation



north of the line of climate limitation, sustaining the necessary temperature for the cost effective recovery of biogas, for energy use from covered lagoons, will not be cost effective in most cases.

4-1.2 What is the Total Solids Content of the Manure?

The solids content of the collected manure is another controlling factor in determining which digester to use. The total solids (TS) content, usually expressed as a percentage, indicates the fraction of the total weight of the manure that is not water.

TS depends on the animal type and the manure management strategy. The animal physiology and feed regimen determines the "as excreted" TS. Manure "as excreted" may have a total solids content from 9 to 18 percent, depending on the animal type. This percentage may be increased by air drying or the addition of materials such as bedding. Adding fresh water, waste water, or recycle flush water lowers the TS of collected manure.

What is the Raw Manure %TS?

The "as excreted" solids value of raw manure for an animal is an average value established by research. Since different animals have different diets, the solids content of their manure - as excreted - differs within a range.

Exhibit 4-2 presents the solids content of manure for various animal types.

Exhibit 4-2 "As Excreted" Value by Animal Type

Animal Type	Total Solids (%)
Swine	9 - 11%
Beef	12 - 13%
Dairy	14 - 16%
Caged Layers	17 - 19%
Broilers	≥ 25%

Source: Loehr, "Pollution Control For Agr 1981

How do the Waste Management Practices affect Manure %TS?

Common waste management practices that decrease and increase manure solids are briefly discussed below. Exhibit 4-3 illustrates how the manure solids change depending on the manure management routine and how these changes affect the digester choices.

Practices that Decrease Solids Concentration

Water dilutes manure. The addition of water to manure may be deliberate (e.g., process water addition) or incidental (e.g., rainfall dilution). Since %TS is the controlling factor in determining which digester to use, knowing the extent of dilution of the solids by water is important. Excess water and increased waste volume can limit the capacity of manure handling and storage facilities. All water entering the waste management system must be accounted for in designing the digester system.

- **Process (Fresh) Water Addition:** Process water dilutes manure solids. In dairies, process water from the milking parlor is the largest new source of liquids reaching the manure management system. Most hog farms spend several days a week washing buildings for sanitation purposes. Water sprays or misters are often used for cooling hogs and cows and may contribute process water. Hogs waste water when drinking or when playing with hog waterers. These practices contribute 1 to 4 gallons of fresh waste water per gallon of hog manure added to the collection system.

- **Flush or Pit Recharge Manure Collection:** Manure may be collected in hog or dairy buildings using recycle flush systems. Hog farms may use a pit recharge collection where 4 to 12 inches of fresh or lagoon recycle water is kept under the floors of the hog building and replaced every week or two. Small farms may use a daily hose wash. Flush collection dilutes fresh manure but delivers fresh volatile solids daily to a lagoon. If all manure is collected daily, then there is no loss of digestible volatile solids. Pit recharge delivers somewhat older manure to a lagoon, with little loss of digestibility. Manure that is collected by flush removal is diluted to less than 2% total solids. Careful management of pit recharge systems may allow collection of manure with up to 3% total solids.

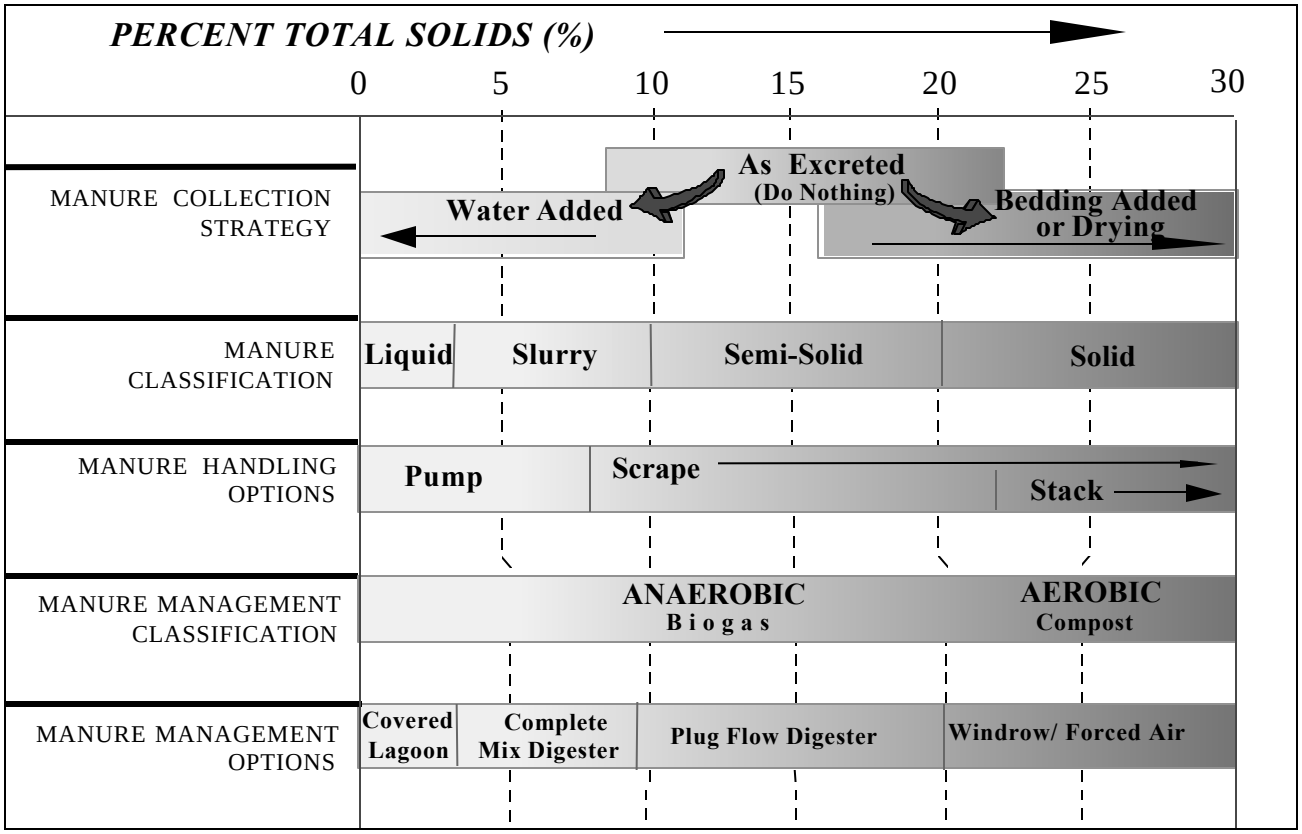
- **Rainfall Dilution:** Manure left on feedlot or open lots during rainfall will be diluted, resulting in lower solids.

Because the quantity of water added to manure varies between farms, the dilution of the solids by water should be evaluated on a site specific basis. Simple ratios of water to manure added are presented in Exhibit 4-4 for different manure handling routines. These are the default values used in FarmWare if no other values are given.

Practices that Increase Solids Concentration

- **Dry Matter Addition:** Solids content of raw manure may be increased by the addition of straw, sand, and sawdust bedding. Bedding materials are generally dry and used to absorb manure liquids. These practices result in solid manure managed by solid manure equipment such as flail manure spreaders.

Exhibit 4-3 Manure Collection and Management Options



– **Sun Drying of Corral Manure:** Manure drying in the sun will have a higher %TS. Often indigestible dirt or stones are collected with corral manure. Manure begins to significantly decompose after one week and is probably not worth collecting for digestion if uncollected for 4 weeks. Typically, these practices are not compatible with biogas utilization strategies, and other waste management options should be considered.

4-1.3 Summary Appraisal

Section 4-1.1 outlined why location was important; Section 4-1.2 described the impacts of manure management practices on manure solids. Using the information from the above two steps, an appropriate digestion technology can be se-

Exhibit 4-4 Matching a Digester to Your Facility

Climate^	Animal Type	Collection System	Estimated Min. Ratio of Water:Manure*	%TS	Digester Type
Warm	Dairy	Flush	10:1	< 2%	Covered Lagoon
		Scrape & Parlor Wash Water	4:1 - 1.1:1	3% - 11%	Complete Mix
		Scrape - Manure Only	N/A	> 11%	Plug Flow
	Swine	Flush	10:1	< 2%	Covered Lagoon
		Scrape	2:1	3% - 6%	Complete Mix
		Pull Plug	5:1	< 2%	Covered Lagoon
		Managed Pull Plug	3:1	3% - 6%	Complete Mix
Cold	Dairy	Flush	10:1	< 2%	Limited possibility for Covered Lagoon
		Scrape & Parlor Wash Water	4:1 - 1.1:1	3% - 8%	Complete Mix
		Scrape - Manure Only	N/A	> 11%	Plug Flow
	Swine	Flush	10:1	< 2%	Limited possibility for Covered Lagoon
		Scrape	2:1	3% - 8%	Complete Mix
		Pull Plug	5:1	< 2%	Limited possibility for Covered Lagoon
		Managed Pull Plug	3:1	3% - 6%	Complete Mix

^ Warm regions are those below the Line of Climate Limitation; cold regions are above the Line of Climate Limitation (see Exhibit 4-1)

* These ratios are default estimates used in FarmWare.

lected for your facility.

Exhibit 4-4 presents a simple table that outlines the digester selection process. Facility operators may use this table to determine which digester is best suited for the farm. This information should not be used in place of the FarmWare water use inventory worksheet.

4-2. Complete Evaluation Forms

Evaluation forms are provided on pages 4-9 and 4-11, for recording the site specific information required by FarmWare to complete the technical and economic feasibility assessment. Forms have been provided for both dairy and swine facilities. It is suggested that additional copies of these forms be made prior to completing them.

Each form contains the following five sections:

1. **Climate Information.** Enter the location (state and county) of the facility.

2. **Farm Type.** Enter the farm type, farm size, manure collection method, and manure treatment method.

3. **Livestock Population.** Enter the number of animals on the farm by animal type.

4. **Manure Management.** Enter information on the manure management routine of the farm.

5. **Energy Information.** Enter the overall energy rates, by season, as well as the monthly breakdown of electricity and propane costs. Appendix G contains a sample letter to a utility requesting a monthly billing history and rate schedules and should be submitted for accurate figures.

These forms should be completed by the person most knowledgeable about the facility. It is expected that this person will also be completing the FarmWare/RateVision analysis.

The evaluation is only as good as the input information. It may be useful to run FarmWare/RateVision several times and change the inputs to see the effects on the output.

For assistance in completing the screening forms or using FarmWare/RateVision call 1-800-95AgSTAR. The National Resource Conservation Service (NRCS) may be of assistance in completing the evaluation forms. See Appendix B for a list of NRCS contacts in your area. AgSTAR participants may elect to mail completed screening forms to the AgSTAR program. The AgSTAR program representative will conduct the FarmWare assessment and report the results of the assessment via mail. Please fill in a contact phone number in case a representative needs to verify information.

4-3. Enter Information into FarmWare and RateVision

FarmWare is a computer software package that enables owners, operators, or others investigating biogas technology as a manure management option to survey their facility, assess energy options, and evaluate system financial performance. RateVision is a separate program that analyzes electric rates as a part of the FarmWare analysis.

To use FarmWare and RateVision, you must have an IBM compatible computer with the following features:

- 386SX or better processor;
- Microsoft Windows 3.1 or later; and
- At least 4 Megabytes of hard disk space.

The FarmWare disks and manual are included in Appendix C. The manual will guide you through the installation and use of FarmWare.

The RateVision disks and manual are included in Appendix D. The manual will guide you through the installation and use of RateVision.

After installing the programs, open FarmWare, and following the manual, input data you recorded in the evaluation form.

Additionally, several case studies showing FarmWare analysis procedures have been presented for your reference in Appendix E. The first group of case studies is for dairy facilities. The next group is for swine facilities. Each set contains two case studies. These studies are examples of typical production facilities and waste handling strategies encountered at dairy and swine facilities. The case studies presented include:

Dairy Case Studies

1. 1,000 Cow Freestall Tractor Scrape Farm;
2. 500 Cow Freestall Recycle/Fresh Water Flush Farm.

Swine Case Studies

1. 1,400 Sow Recycle Flush Farrow-Finish Farm;
2. 1,500 Sow Pull-Plug (Pit-Recharge) Farrow-Grower Farm.

4-4. Evaluate Results

Project economics depend on a number of site specific factors, such as the details of the manure management system, farm energy needs, energy billing, and regulatory requirements. These factors affect the potential amount and quality of recoverable methane and consequently affect the potential revenues (or savings).

FarmWare together with RateVision estimates the costs and revenues from the project and presents the results in the *Quick Financial Report* screen. This screen also shows results for the three main techniques for assessing the economic feasibility of the project:

- **Payback Method.** The payback method involves determining the number of years it would take for a project to generate profits equal to the initial capital outlay. This method may be particularly suitable where there is a great amount of risk and uncertainty associated with a project and the emphasis is on recovering capital expenditure as quickly as possible. The main disadvantages of this method are: it does not consider the costs and benefits that accrue at the end of the payback period; and it takes no account of the time when costs are incurred or benefits are received. The payback method is appropriate to use when making a rough preliminary assessment of a project's economic feasibility.

- **Discounted Cash Flow Method (Net Present Value).** The basic premise of the discounted cash flow technique is that costs or benefits occurring in the future are worth less than those occurring now. This means that annual costs and benefits are not simply added up over the years of the project. The costs and benefits in each year of the project are adjusted by a discount factor so that costs or benefits occurring in one year can be compared with the costs or benefits occurring in another year. The discounted costs and benefits in each year can be aggregated to give a **net present value** of future cash flows of the project. The discount rate used will normally be chosen on the basis of prevailing interest rates or on the basis of the minimum desired rate of return for the project. If the net present value is zero or greater, the appraisal shows that the project is capable of yielding the threshold of return.

- **Internal Rate of Return Method.** The internal rate of return is the discount rate at which the net present value of the project would be zero. This value shows the total rate of return achieved by the project. This rate can be compared to return rates from alternative investment opportunities.

Sensitivity analyses should be done to examine how changes in key parameters such as electricity prices can affect the economic viability of the project. These sensitivity analyses can be carried out

before the financing arrangements for the project have been worked out and are useful in providing an initial indication of the project's viability. Further analysis can be conducted to examine the implications for viability of different financing schemes.

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